Search for New Physics with Atomic Clocks near the Sun

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Atomic clocks play an important role in defining the boundaries of various theories of physics. In space, the combination of a benign environment that results in higher performance clocks, and a significant deviation from gravity on the surface of Earth, provides a unique opportunity to test some of the most important questions facing the present day physics: Are nature's constants really constant, or have they changed over the evolution period of the Universe? How can gravity be reconciled with quantum theory? What lies beyond the standard model of fields and particles? These questions are the subject of a new space mission concept that is a proposal to NASA. The mission, SpaceTime, is designed to search for new physics by measuring a differential frequency shift near the Sun with clocks. The proposed mission entails a unique clock package consisting of three ion trap based clocks within the same enclosure. The spacecraft and the clock are designed to maintain very high differential stability during the six solar radii flyby. The three clocks, based on mercury, ytterbium , and cadmium ions, are designed to share their local oscillator, thermal, magnetic, and vacuum environment, thus allowing cancellation or identification of non-gravitational perturbations. With this scheme, a precise differential measurement of the gravitational redshift at one part in 10^10 is possible. This sensitivity is six orders of magnitude larger than the previous (GP-A) clock redshift test in 1976. SpaceTime allows a search for the variation of the fine structure constant (alpha), with four orders of magnitude more sensitivity than the current best limits. This sensitivity allows probing for new physics, and will have important implications for questions regarding the nature of the dark energy, and the evolution of the universe. In this talk the science investigation, the "tri-clock" payload, and the mission design will be described in detail.